



Edgewood Chemical Biological Center

Disparate Sensor Integration for CB Defense

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Objective

- Application of non-CB, force protection sensors in Chemical/Biological detection
- Sensors to be used in a dual use mode
- Earliest warning capability, detection made seconds after explosion



Type of sensors used

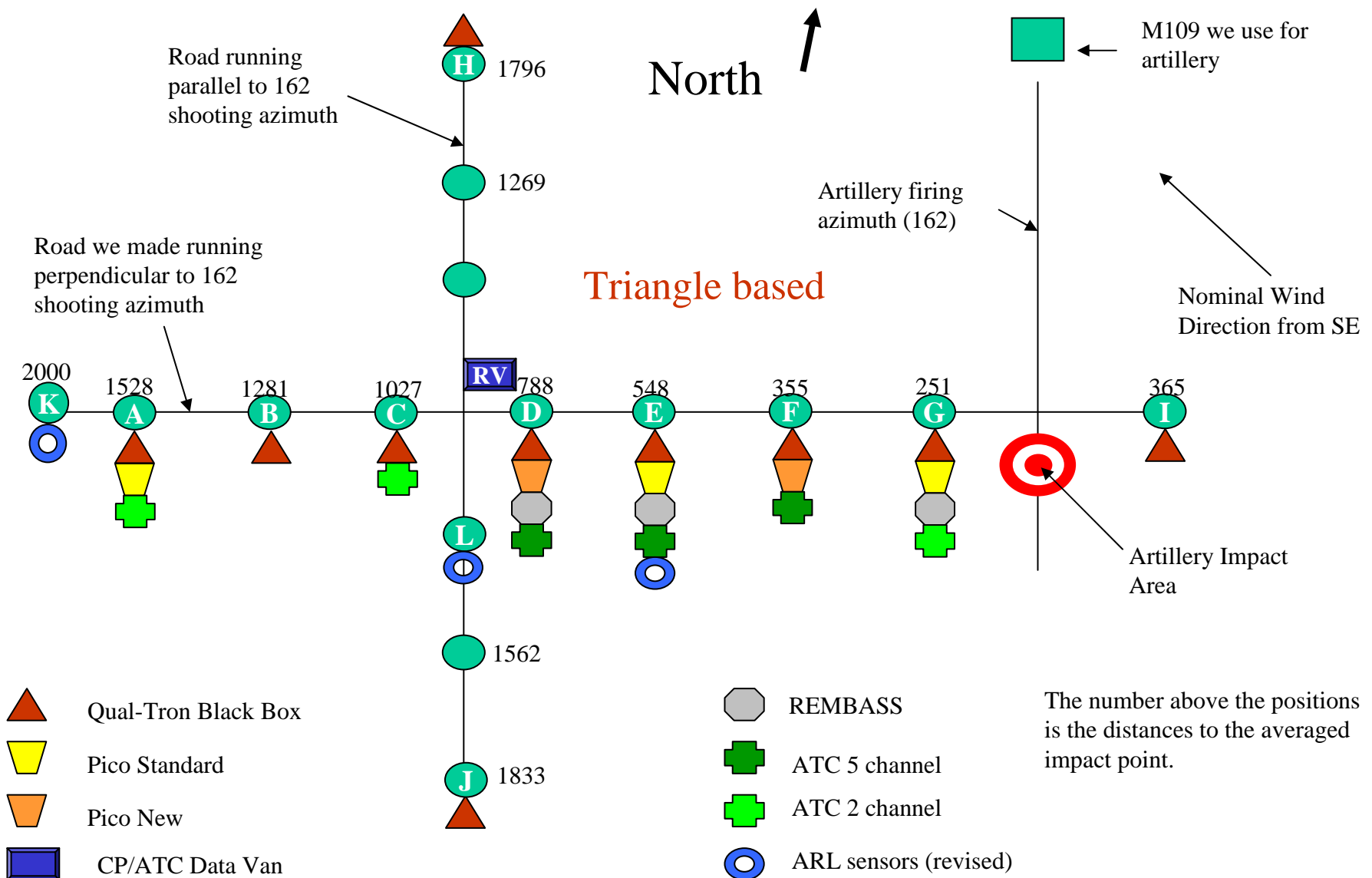
- Acoustic
- Seismic
- Visible Cameras
- Infrared Cameras
- Existing intrusion sensors



Field Test

- Total of 260 155 mm artillery rounds
 - Equally divided between conventional and simulated CB rounds
 - Equally divided between air burst and point detonation
- Order of fire was random
- First 160 rounds are used for algorithm development
- Last 100 rounds are blind shots used to test the reliability of the algorithms

Sensors Layout



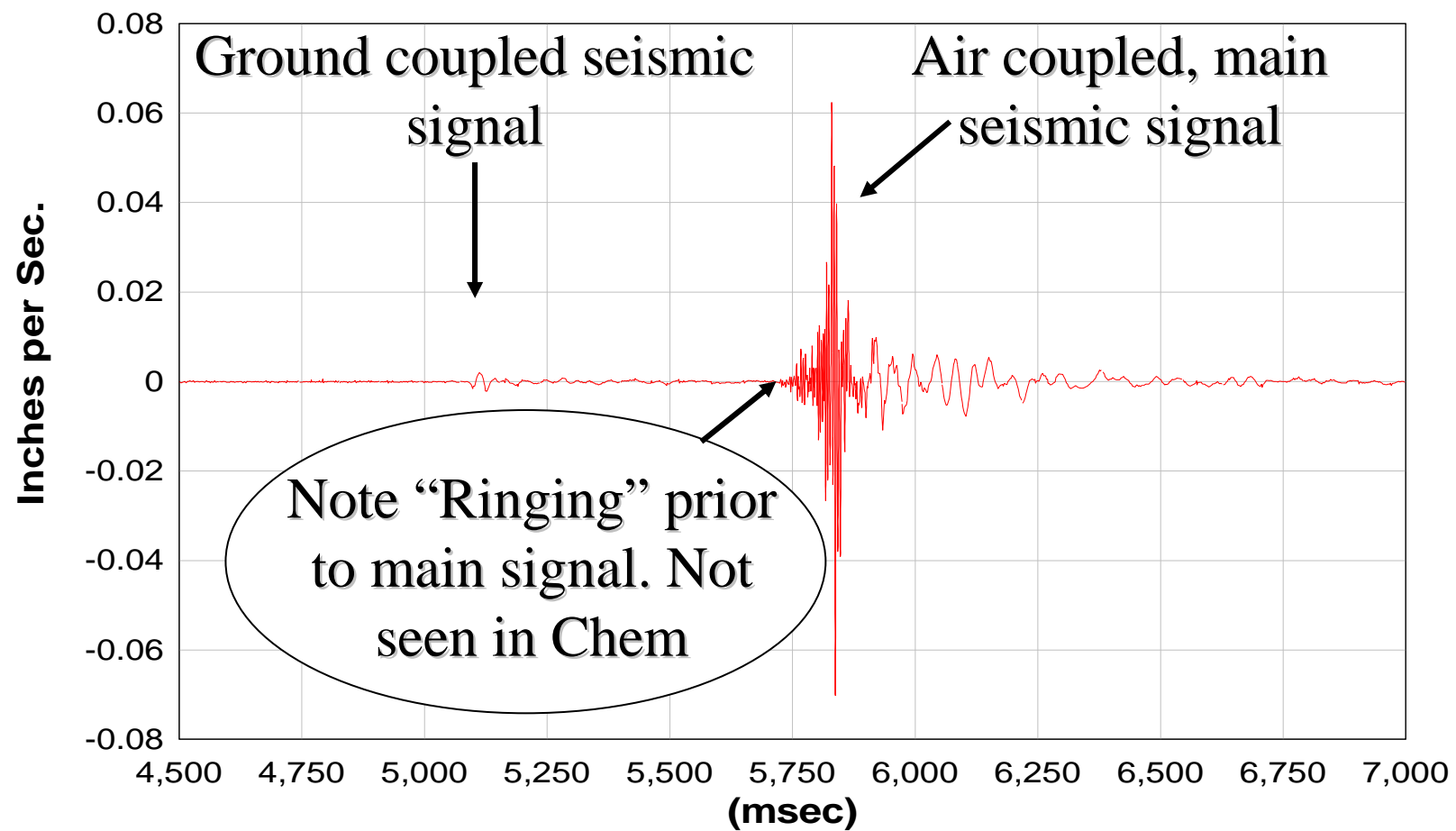


Initial Analysis

- Difference in maximum intensity between the HE events and the Chemical simulated events
- A “pre-ringing” effect occurred before the HE events



HE Seismic Signature





Status

- Several algorithms based on single sensor signatures were developed from
 - Acoustic signature
 - Seismic signature
 - IR signature

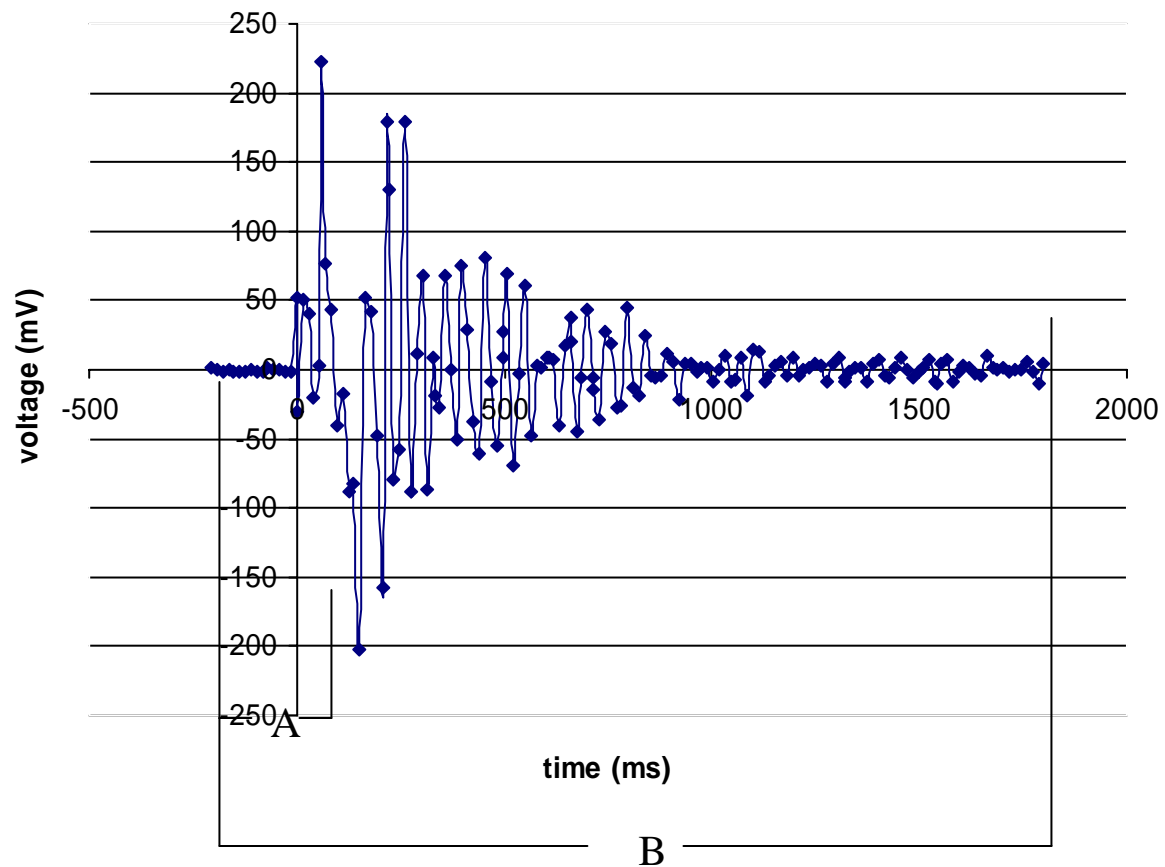


Seismic Analysis

- Ratio between time to seismic signal maximum (A) to total length of seismic signal (B) can differentiate between CB and HE rounds (Initial data – 90% accurate)



Example of the Seismic Ratio

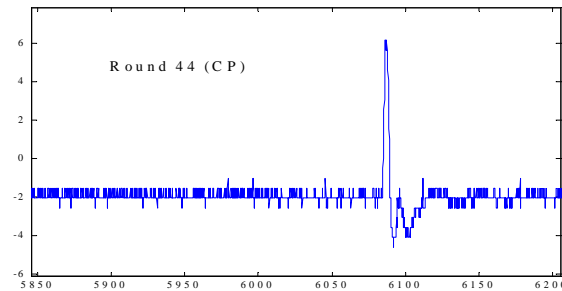
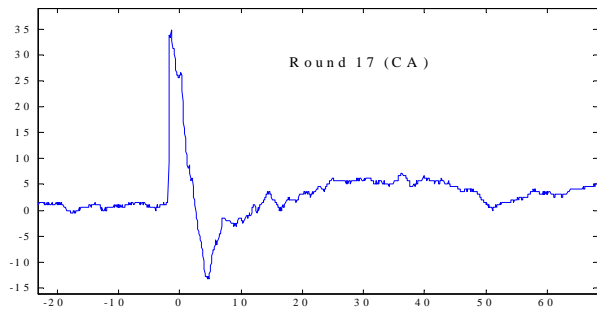
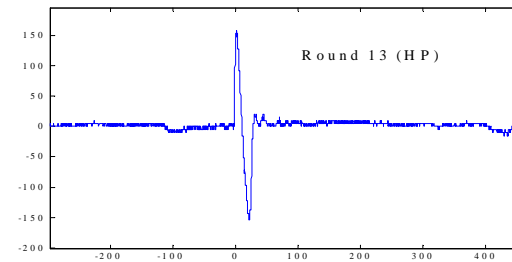
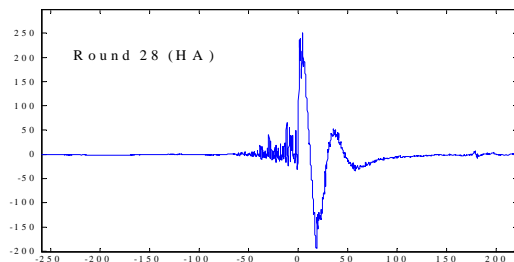




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Acoustic Analysis

- The area under the positive peak is a good discriminator





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Integrated Area Under the Positive Peak

	HE		Chemical	
	Air Burst	Point detonation	Air Burst	Point detonation
Mean	0.534	0.356	0.0385	0.00538
STD	0.0798	0.0586	0.0107	0.00687
<i>mean</i> \pm <i>STD</i>	0.454-0.614	0.297-0.415	0.0278-0.0492	0-0.0123
<i>mean</i> \pm 2 <i>STD</i>	0.374-0.694	0.239-0.473	0.0171-0.0599	0-0.0191
<i>mean</i> \pm 3 <i>STD</i>	0.295-0.773	0.186-0.532	0.0064-0.0706	0-0.0260



Results and Performance

- If area under positive peak < 0.11 Pa then a chemical event occurred
- Further discrimination of a chemical rounds mode of detonation is possible
 - Area < 0.02 Pa – chemical point detonation
 - $0.02 \text{ Pa} < \text{Area} < 0.11 \text{ Pa}$ – chemical air burst
- The algorithm was able to determine if an event was chemical or conventional with 100% accuracy
- It was correct 47 out of 48 times on the mode of detonation



IR camera Analysis

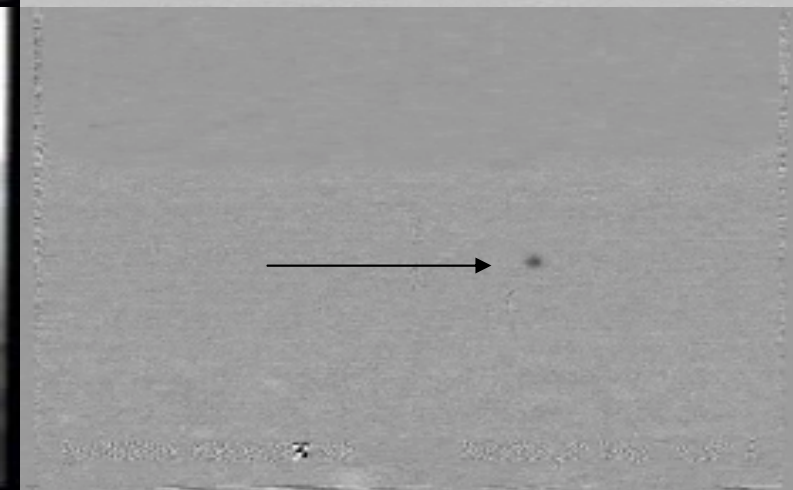
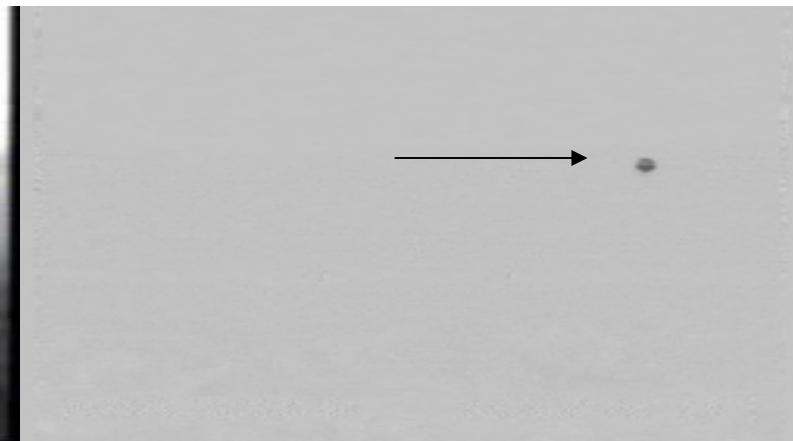
- Discrimination characteristics include
 - Size of fireball
 - Shape of fireball (Eccentricity)
 - Duration of the fireball
 - Grey scale of the image
 - Rate of expansion



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First frame after detonation

Top: HE round Bottom: Chemical Simulant Round



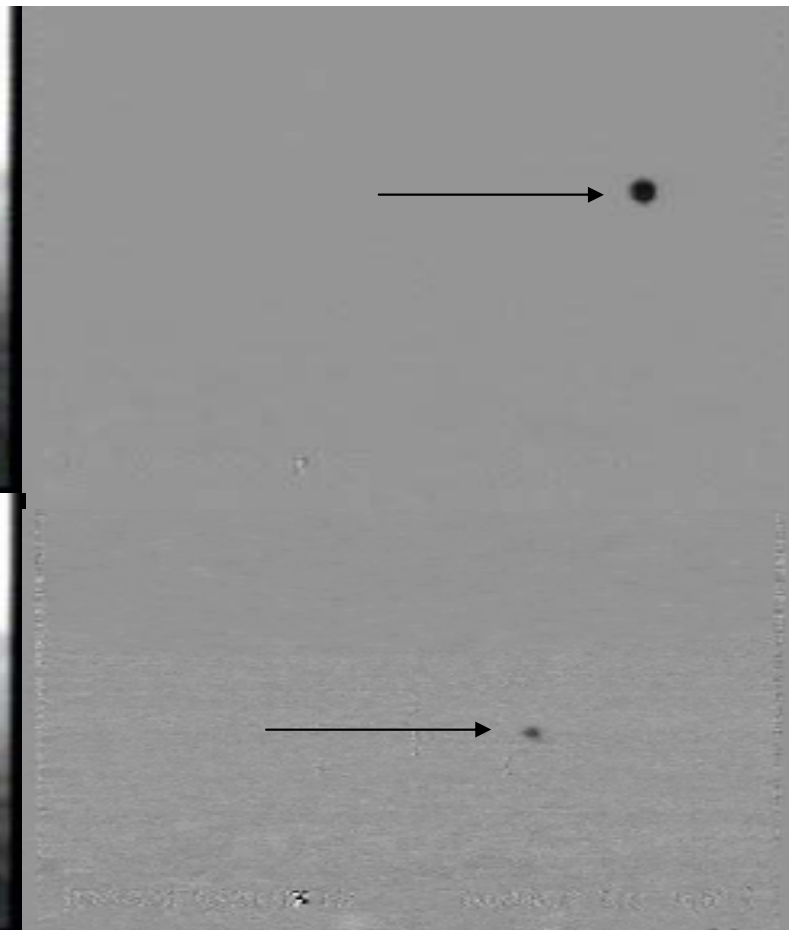


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Second frame after detonation

Top: HE round Bottom: Chemical Simulant Round





Observation

- Chemical simulant air bursts have a larger gray scale and shorter duration
- Fireball HE air bursts expand faster
- HE point detonation have a larger eccentricity value
- Chemical simulant point detonation has all negative values for growth



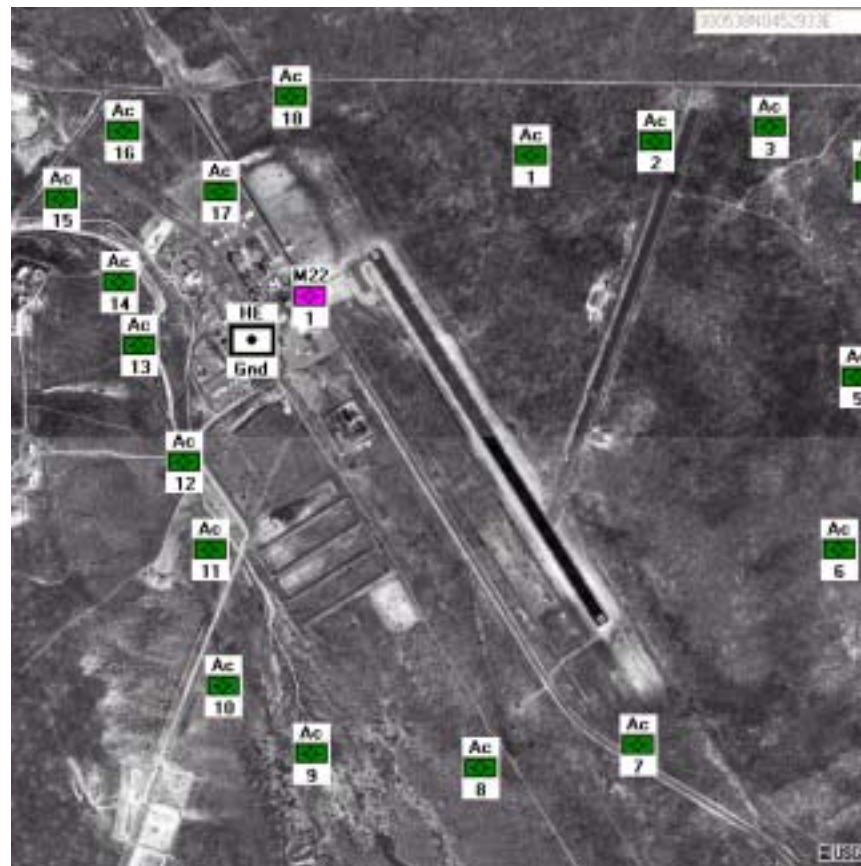
Modeling and Simulation Effort

- Acoustic/Seismic as $1/r^2$ function
- Decision process based on intensity only
- Support multiple sensors and sensor types
- Scableable
- Manual placement of sensors/events
- Supportable to the future
- Capture and display interactions of non-CB sensors to event
- Capture response by CB sensors



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Modeling and Simulation of HE and Chemical events on a Fixed Site





Modeling and Simulation

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Example 1

Type of Event: HE

Sensors:

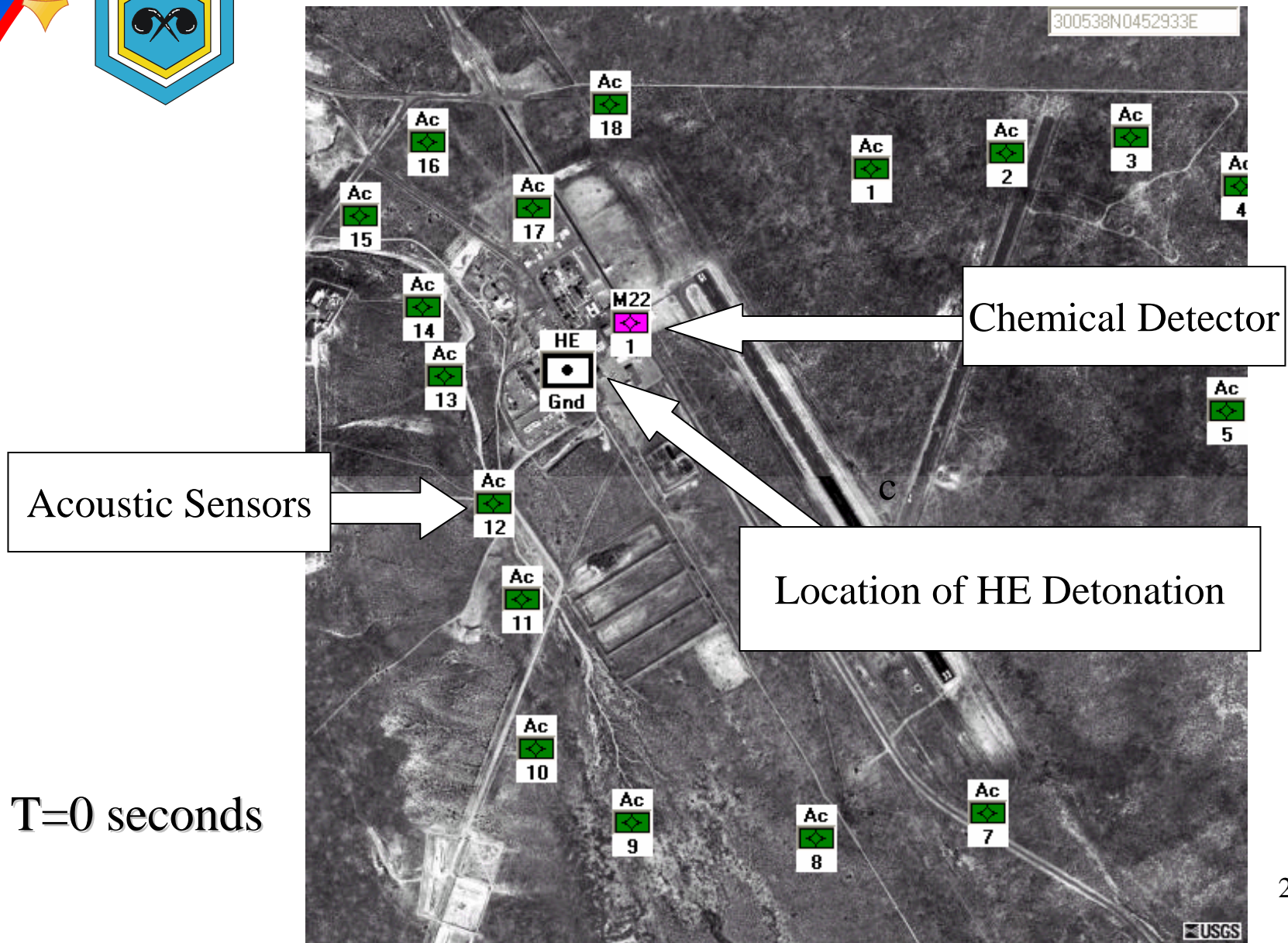
ACOUSTIC

CHEMICAL - M22



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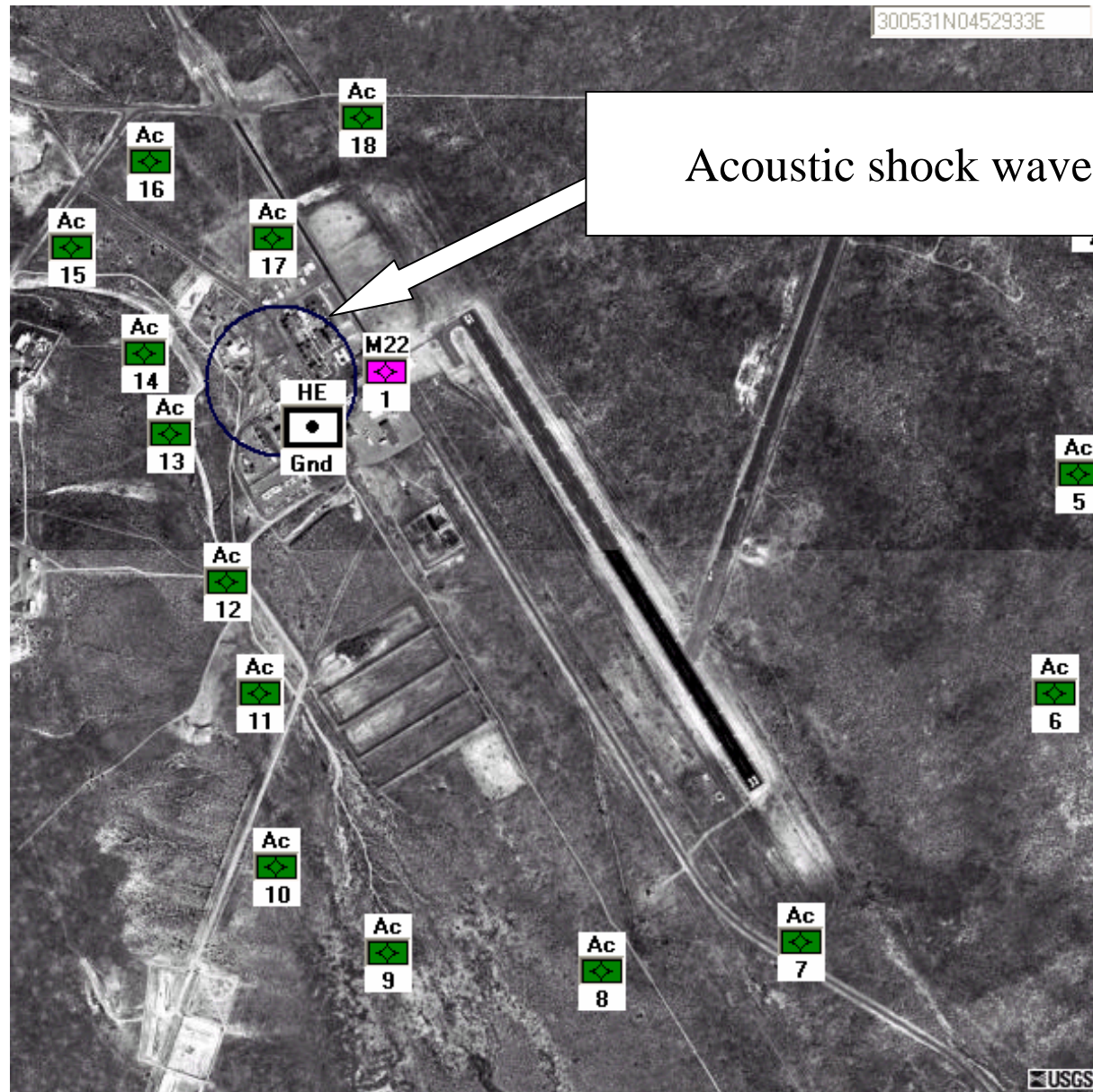
Modeling and Simulation





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Modeling and Simulation

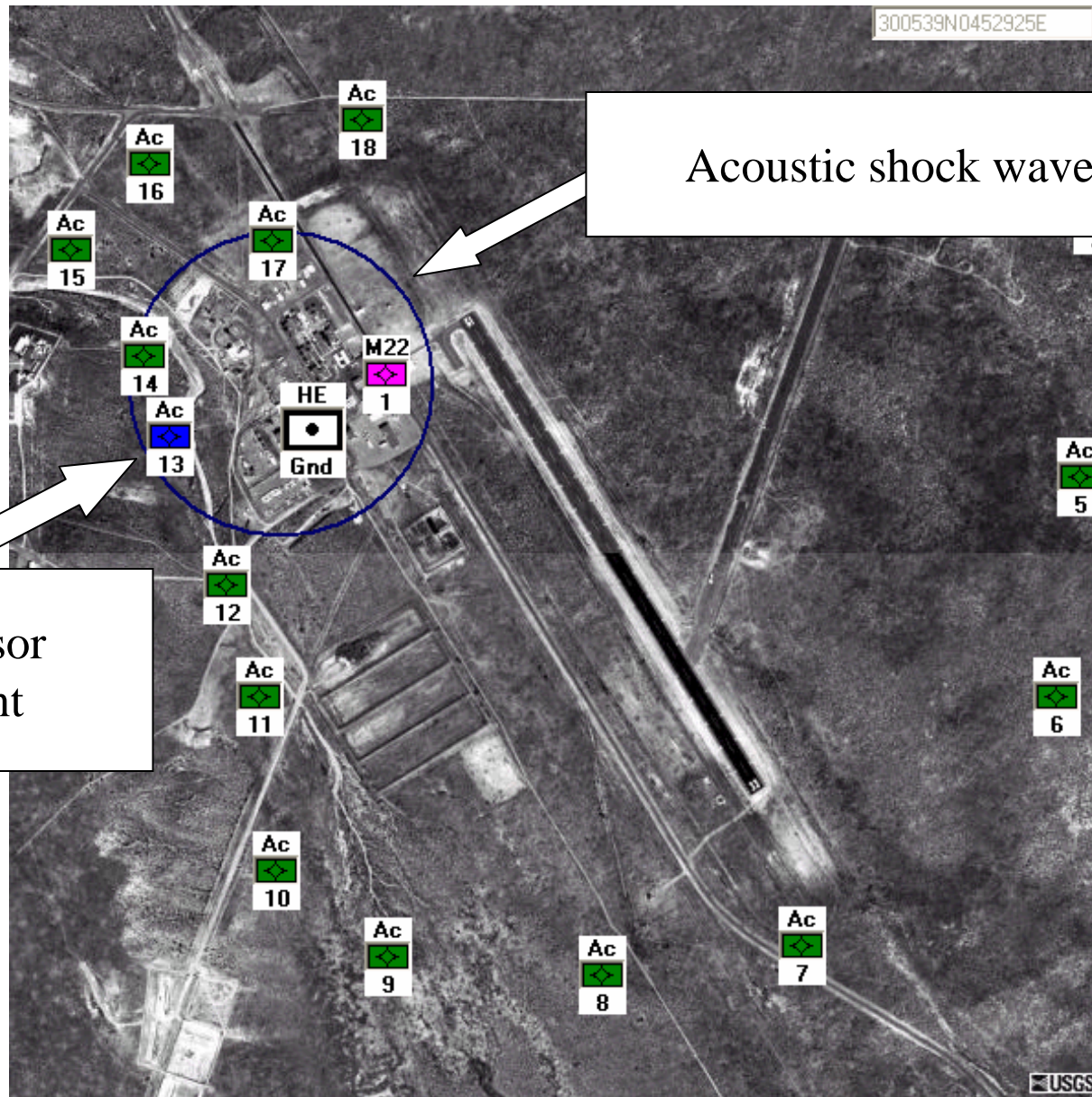


T=1 seconds



Modeling and Simulation

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Acoustic sensor
detects event

Acoustic shock wave

$T=2\text{seconds}$



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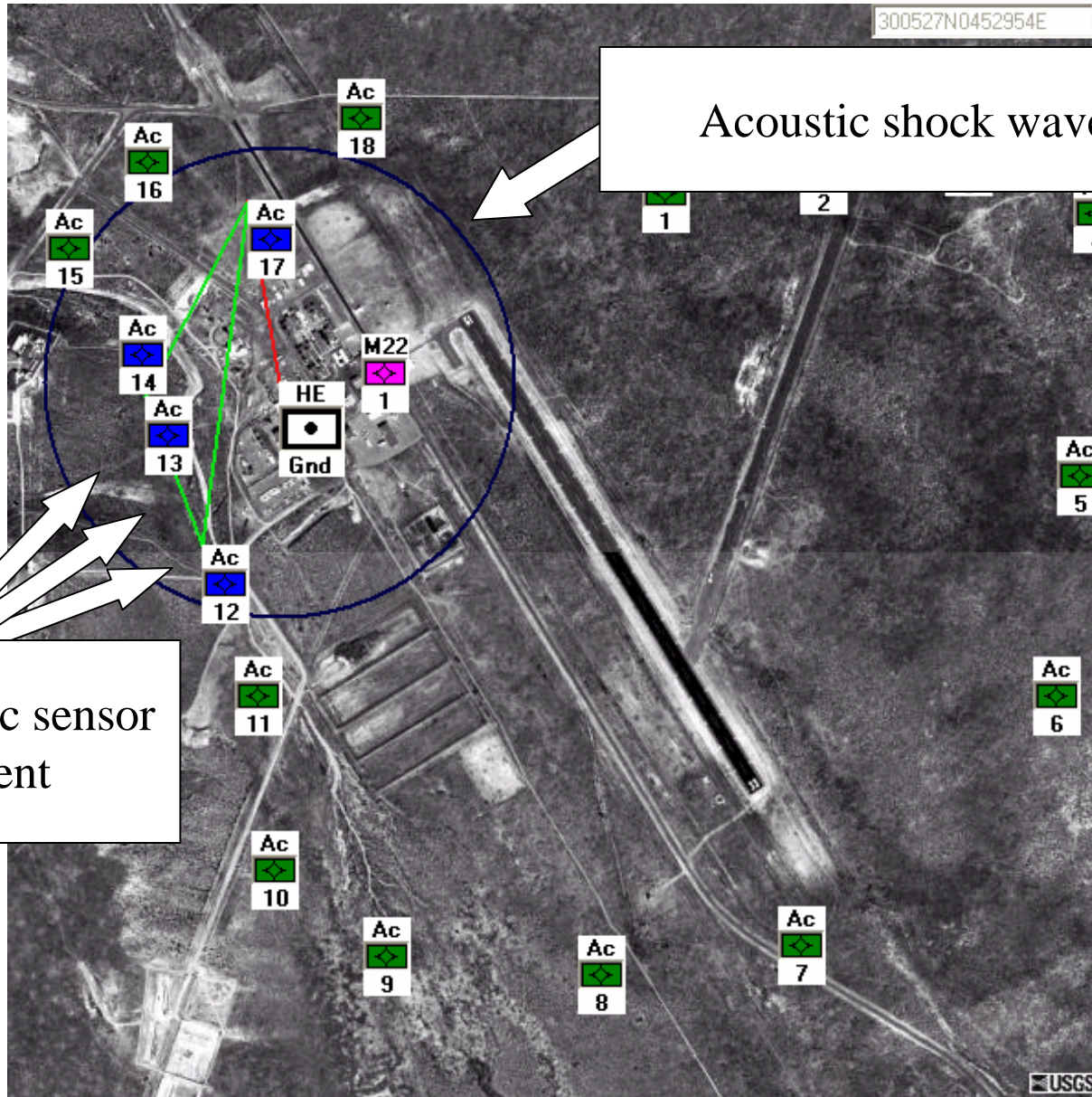
Modeling and Simulation

300527N0452954E

Acoustic shock wave

Multiple acoustic sensor
detects event

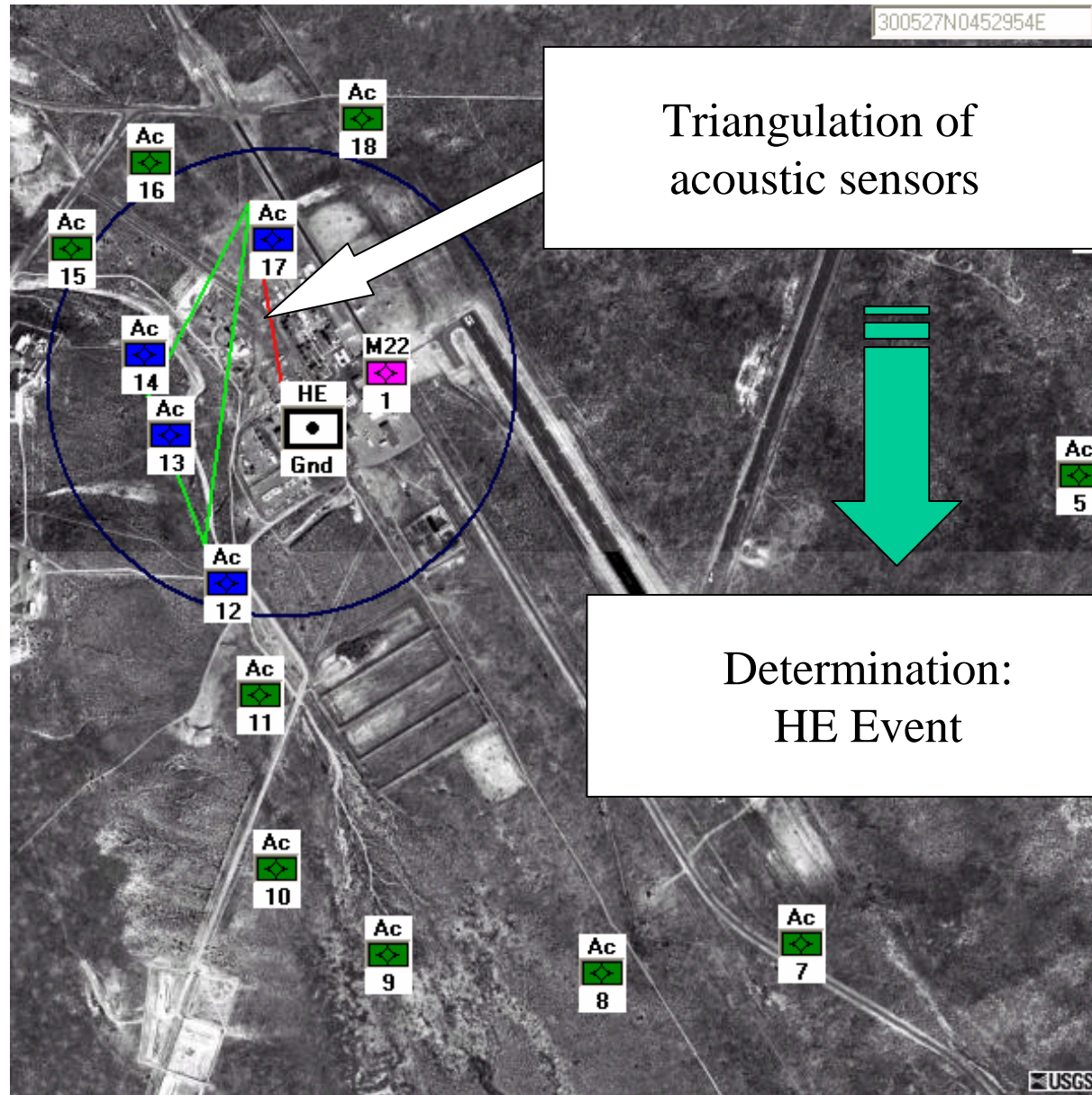
T=3seconds





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Modeling and Simulation



T=3seconds



Modeling and Simulation

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Example 2

Type of Event: Chemical

Sensors:

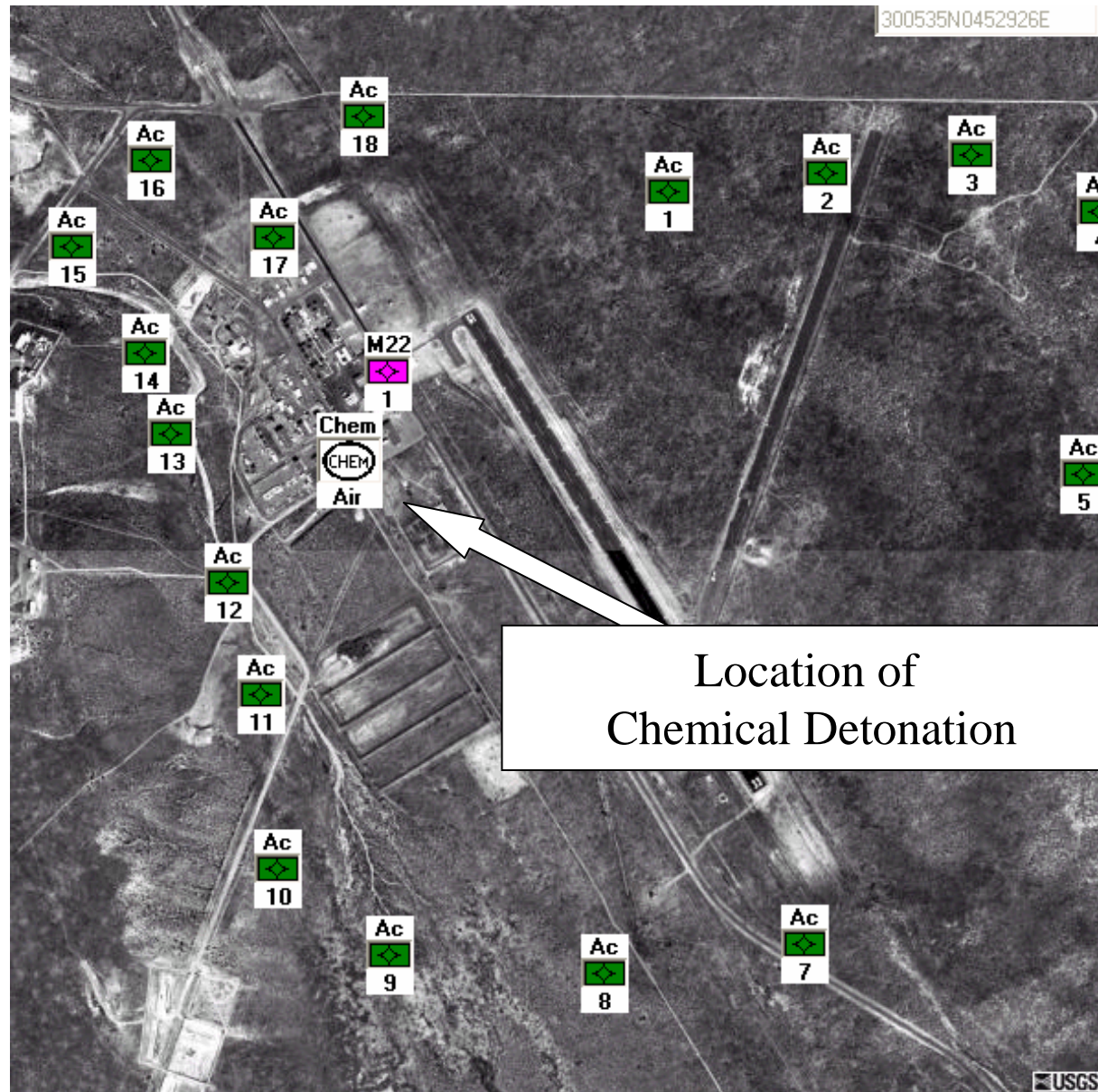
ACOUSTIC

CHEMICAL - M22



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Modeling and Simulation

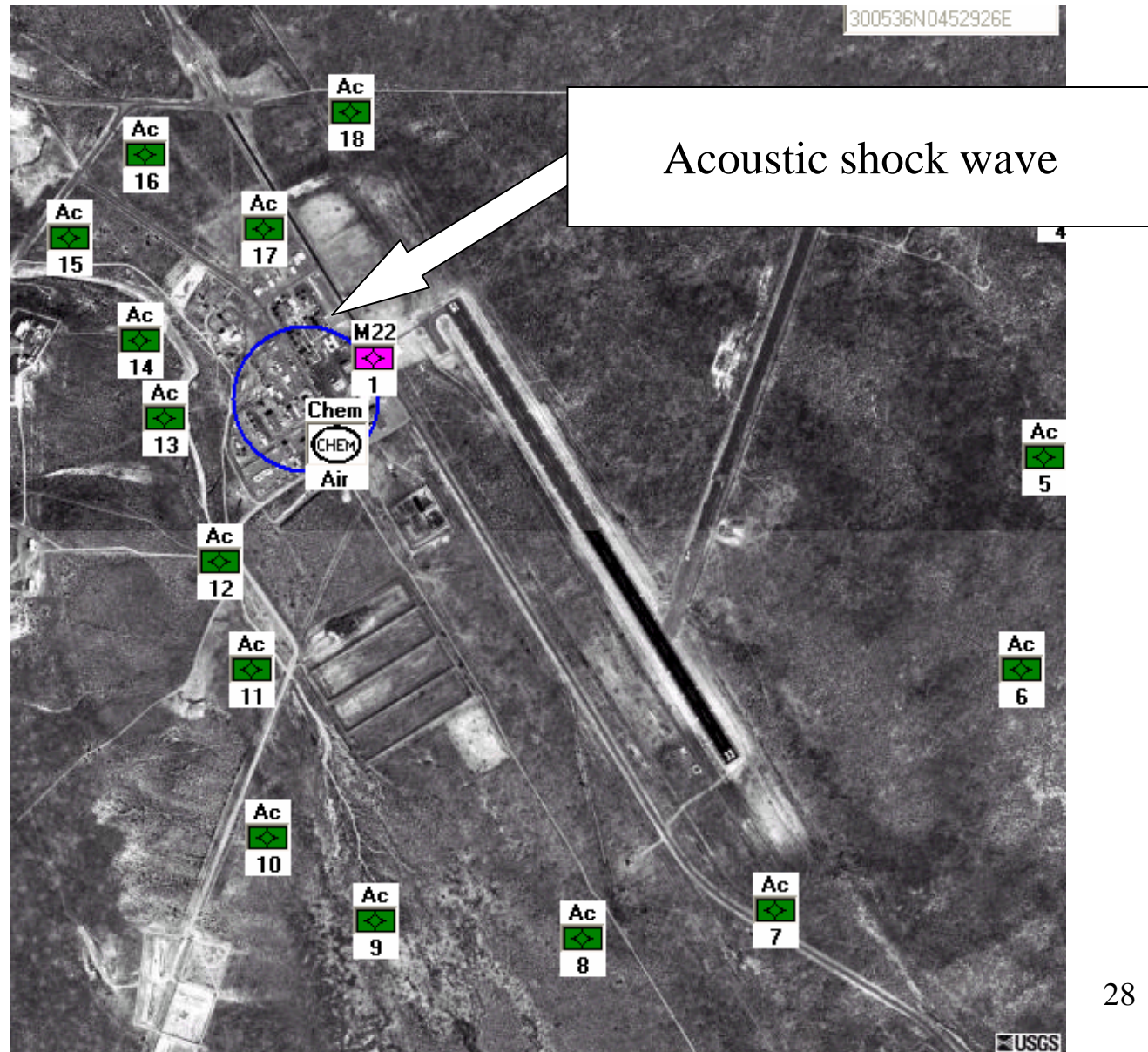


T=0 seconds



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Modeling and Simulation

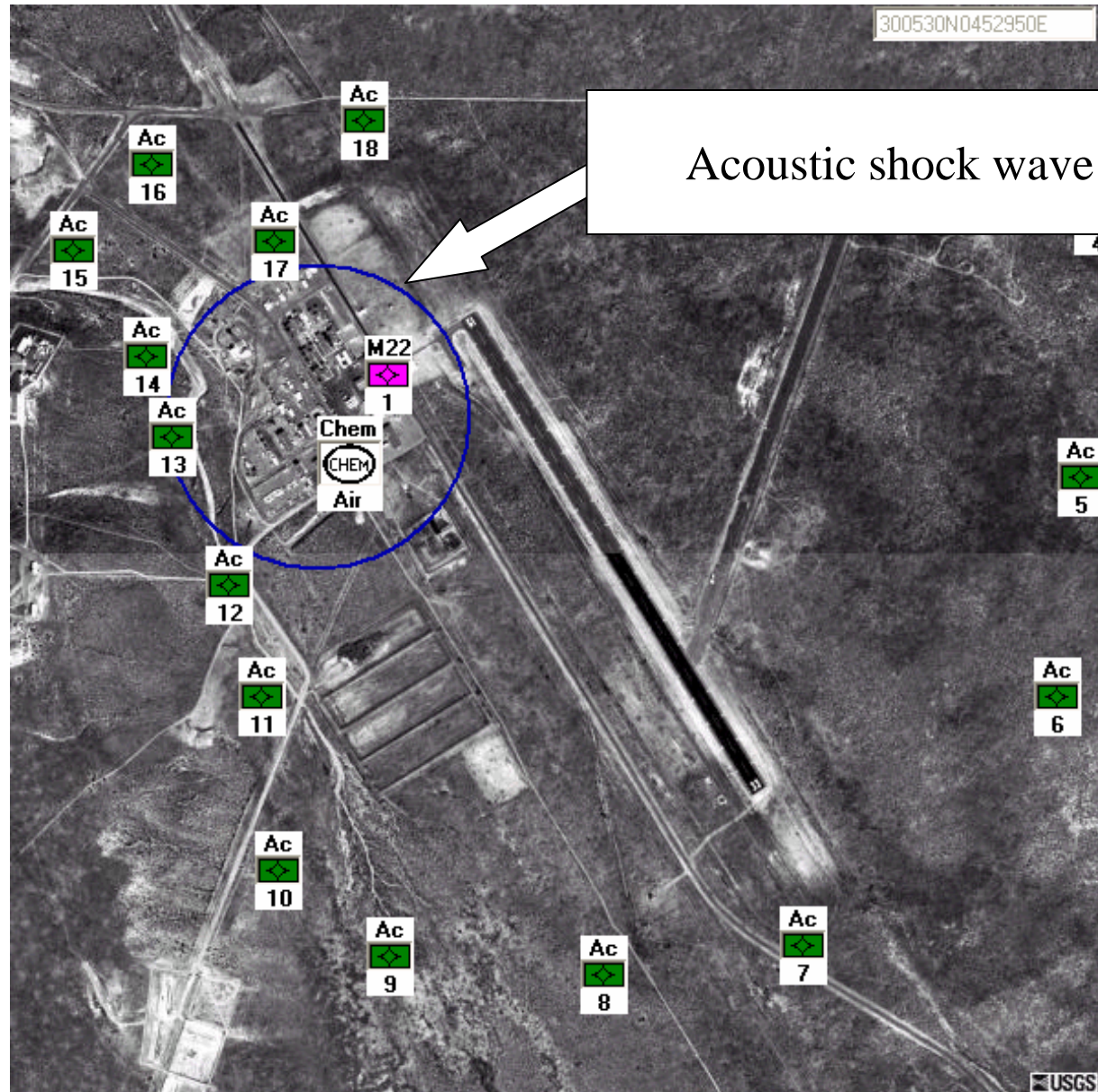


T=1 seconds



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Modeling and Simulation

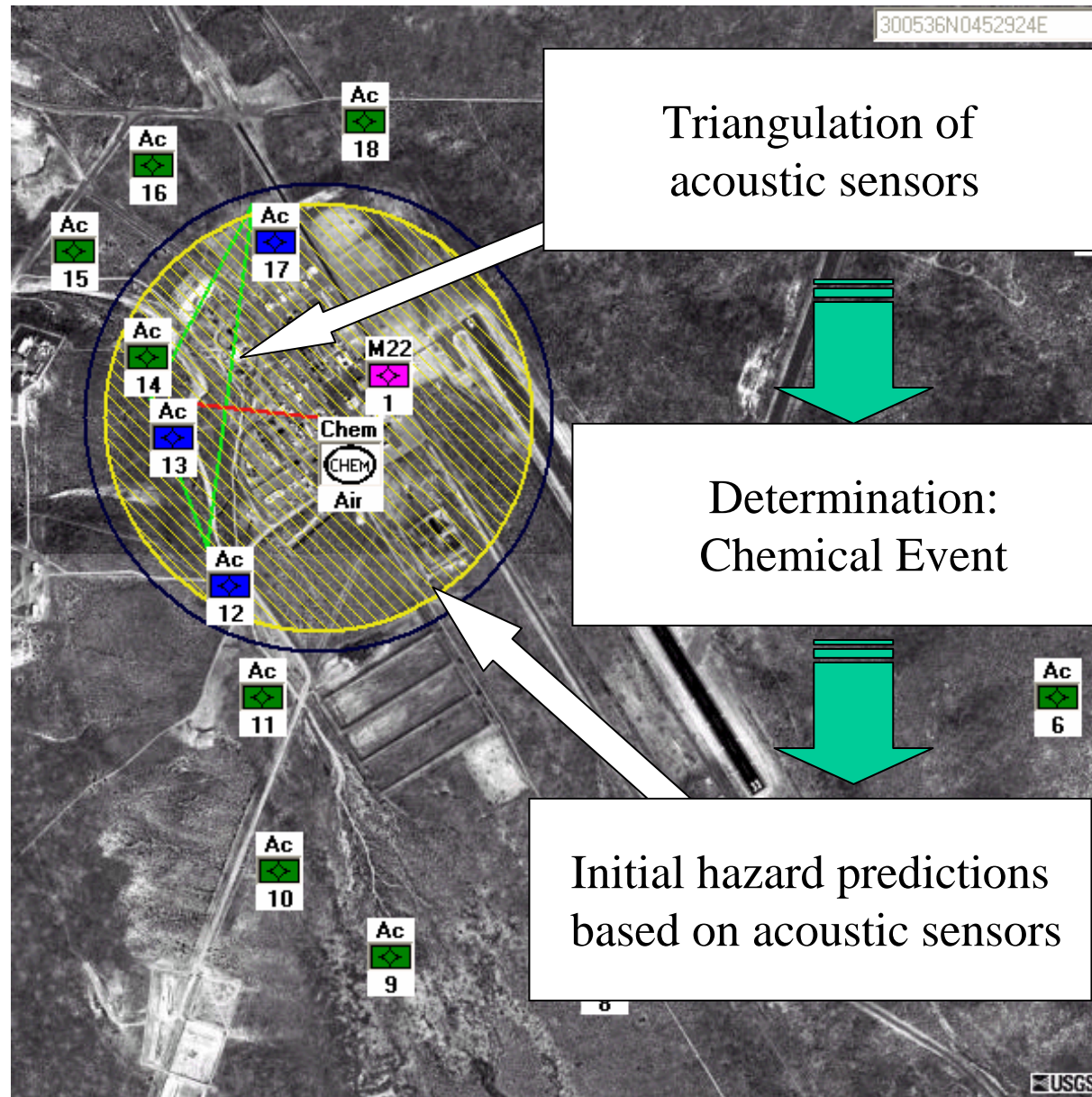


T=2 seconds



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Modeling and Simulation



Triangulation of
acoustic sensors

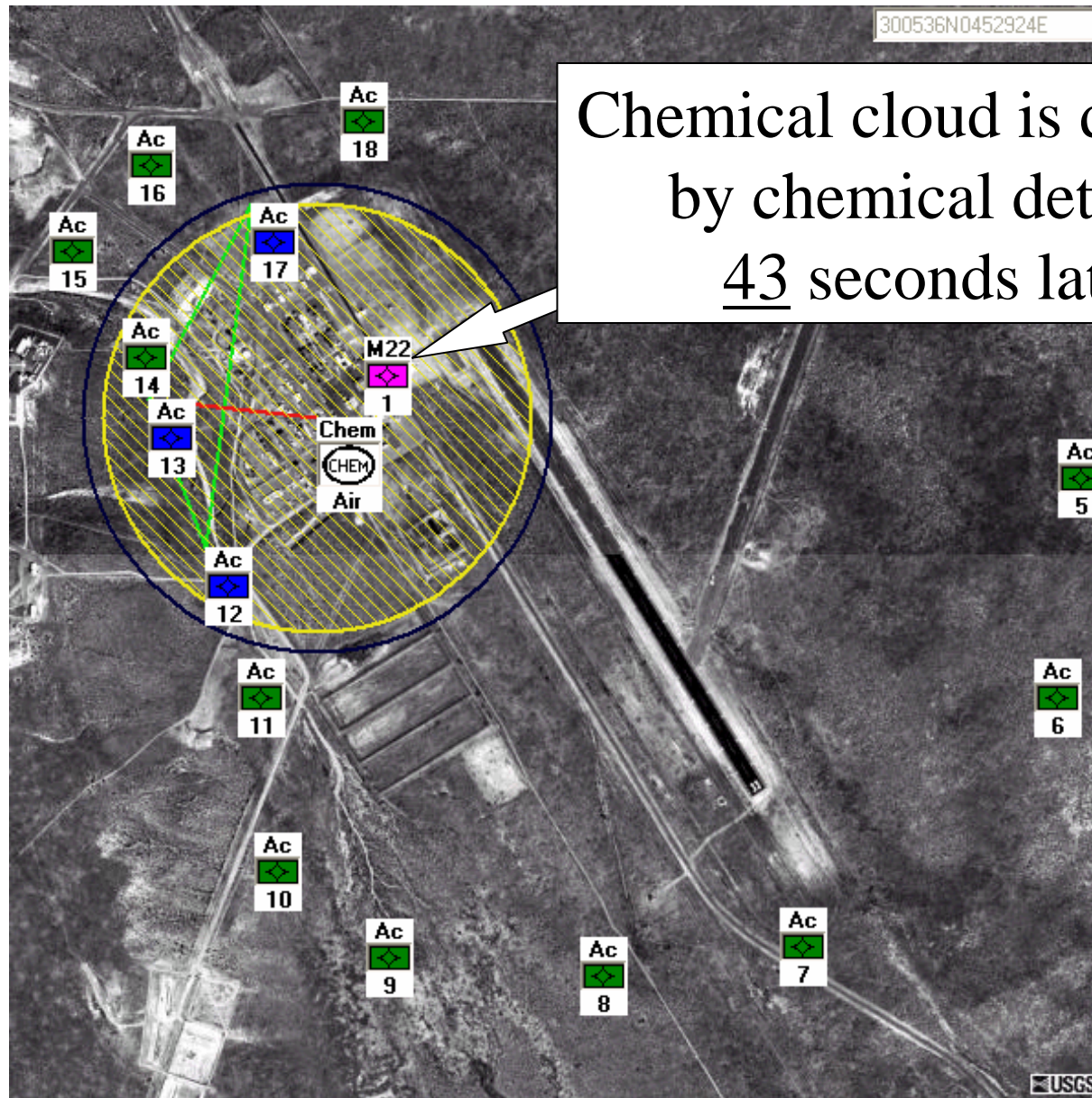
Determination:
Chemical Event

Initial hazard predictions
based on acoustic sensors

T=3seconds



Modeling and Simulation



Chemical cloud is detected
by chemical detector
43 seconds later



Modeling and Simulation

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Example 3

Type of Event: Chemical

Sensors:

ACOUSTIC

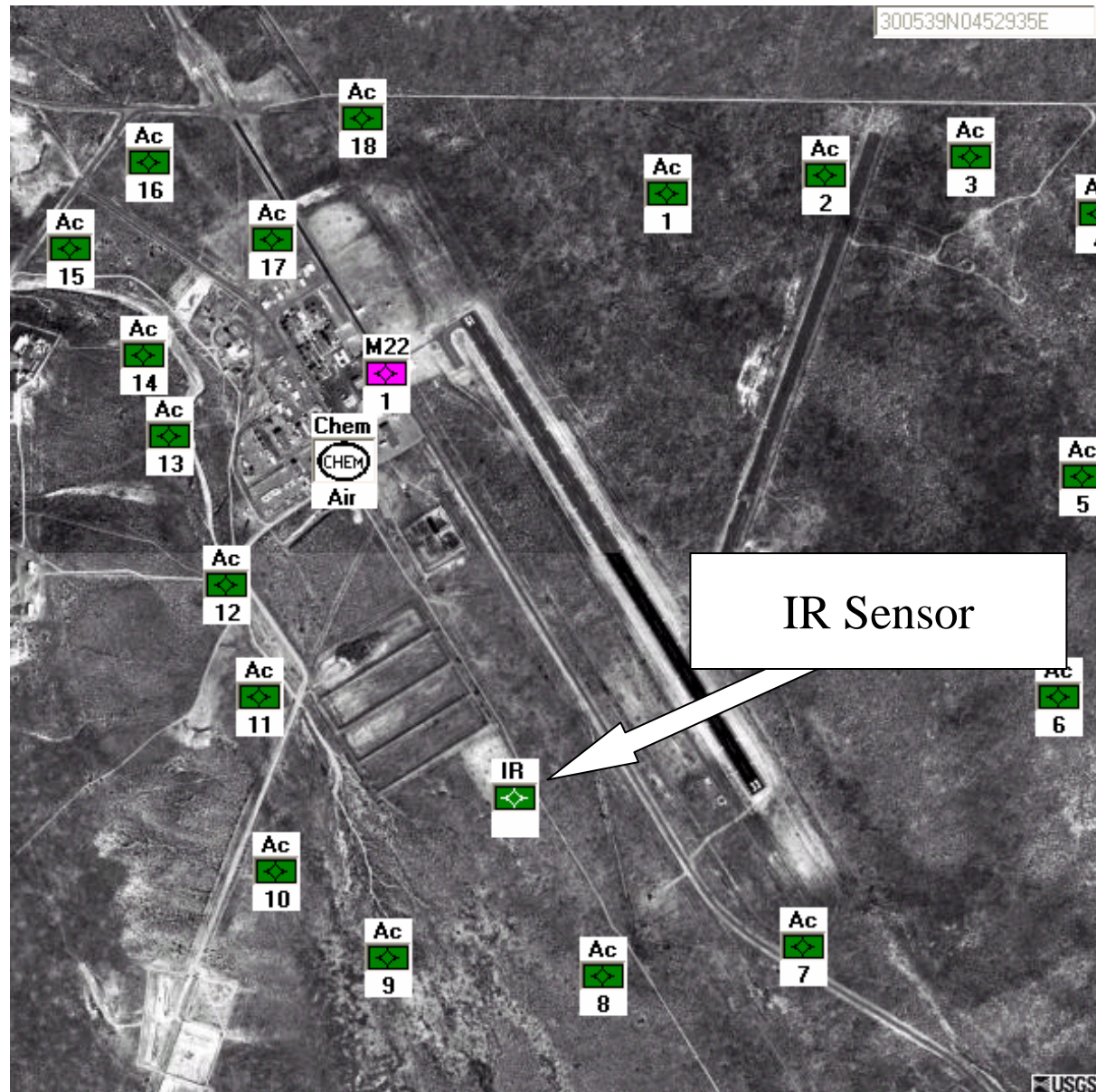
CHEMICAL - M22

IR



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Modeling and Simulation

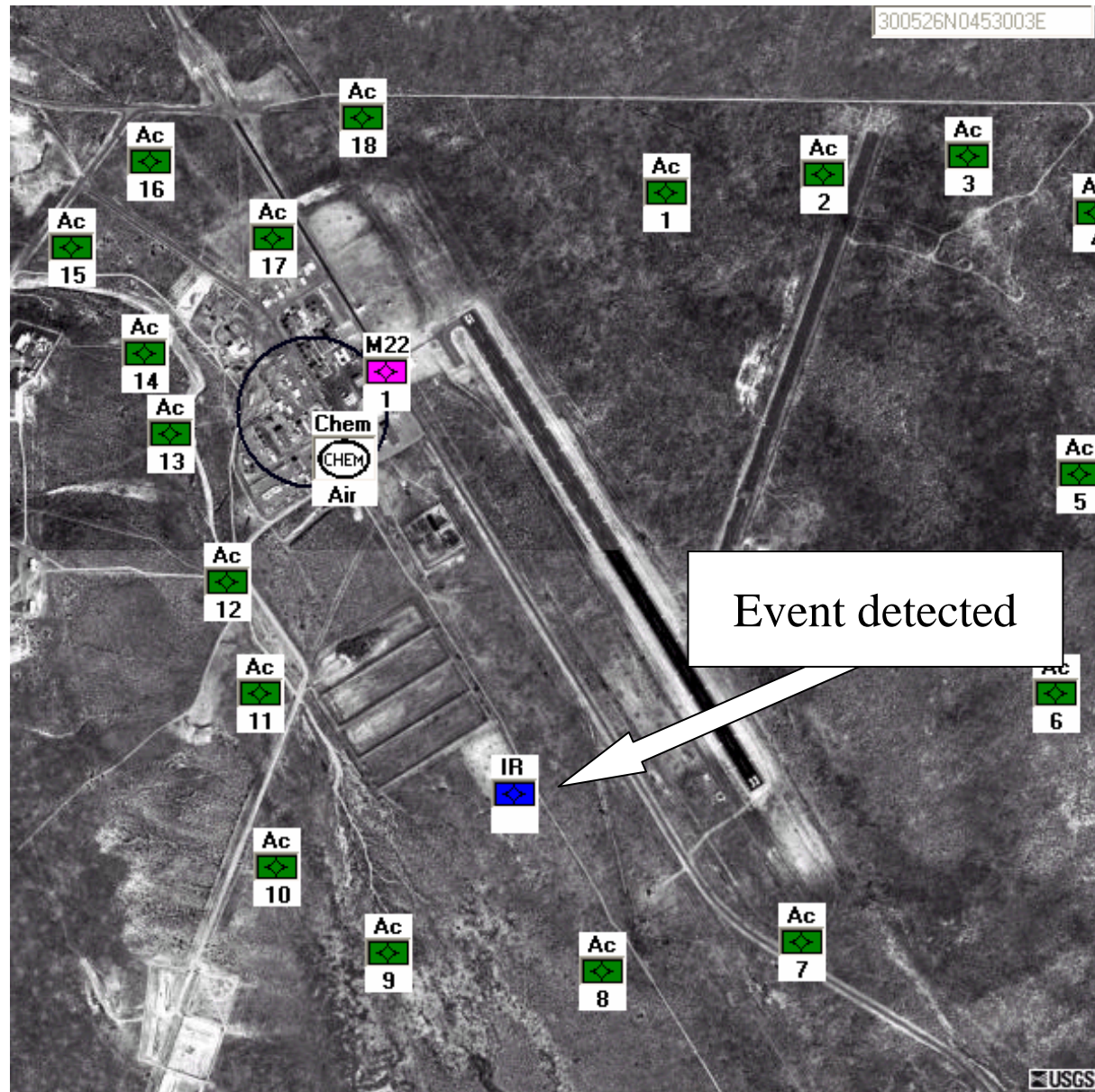


T=0 seconds



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Modeling and Simulation

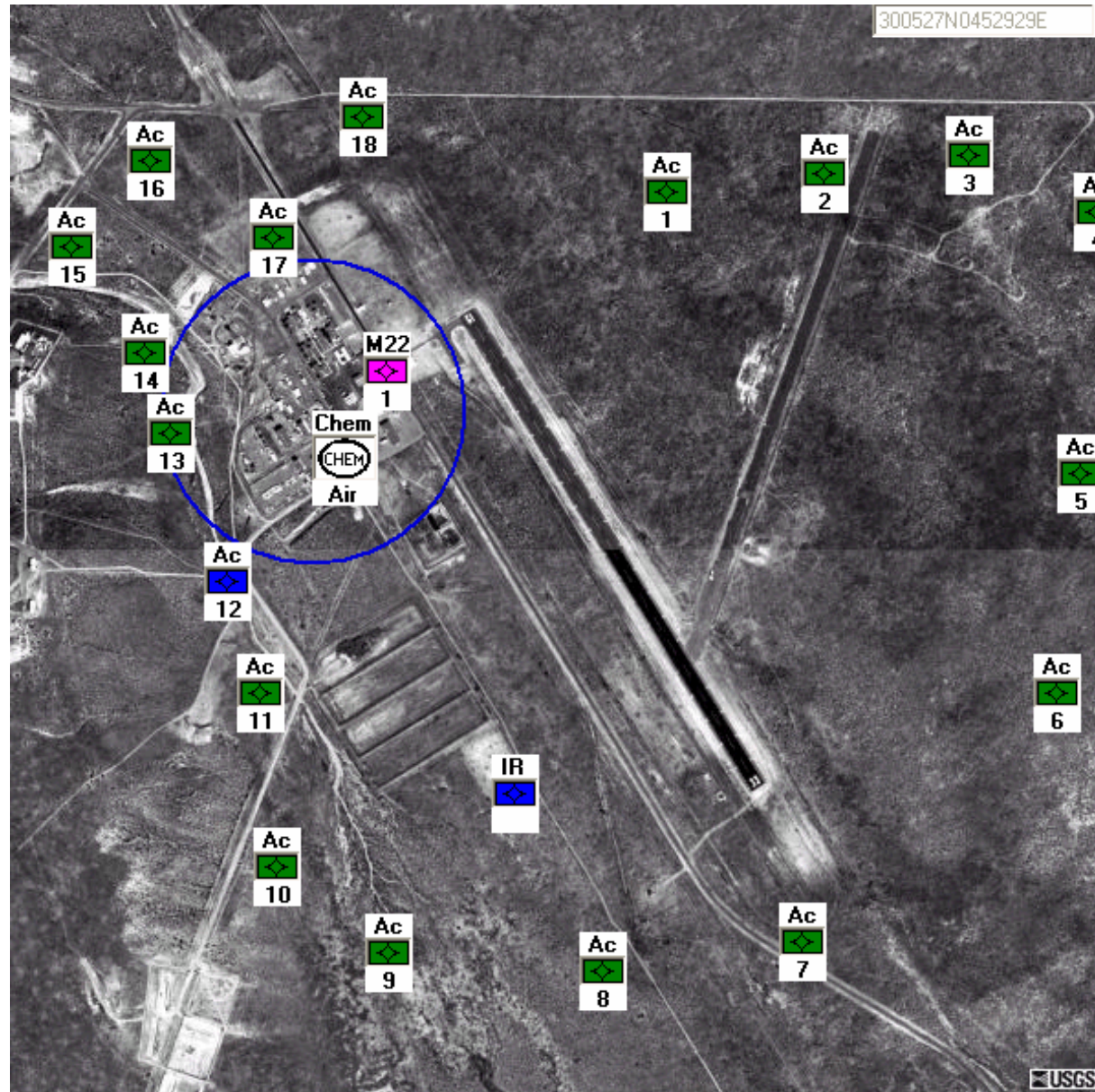


T=1 seconds



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Modeling and Simulation

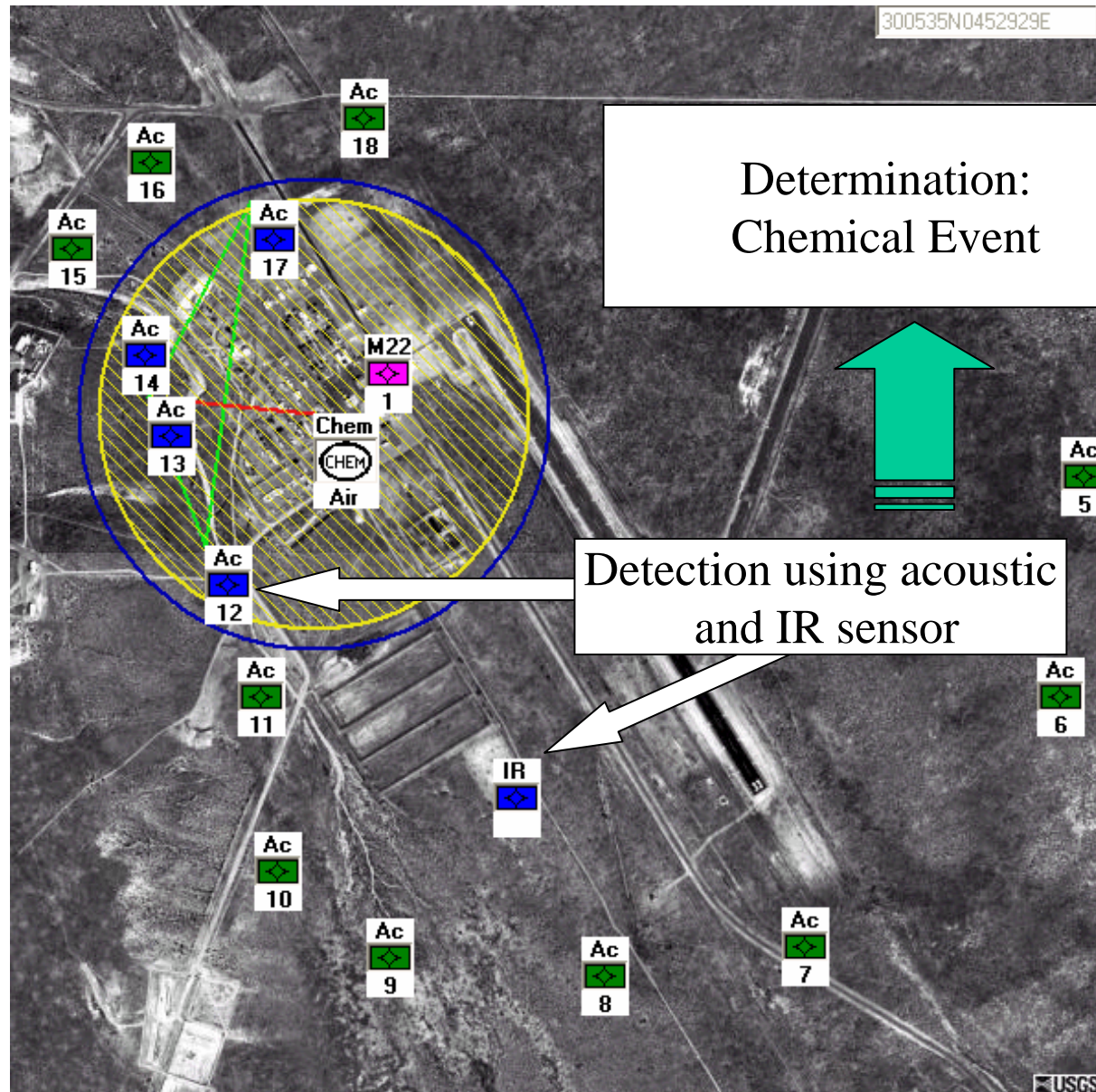


T=2 seconds



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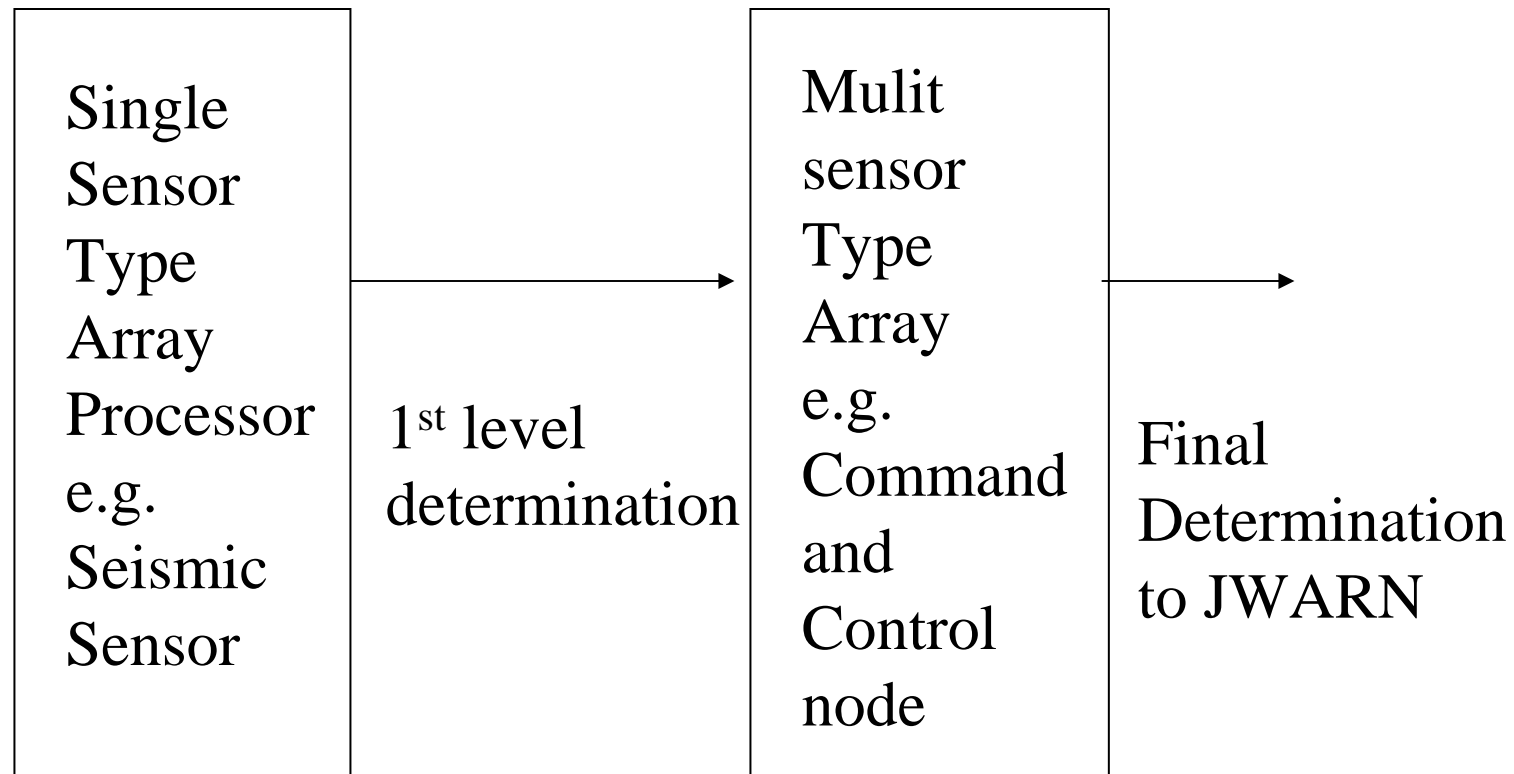
Modeling and Simulation



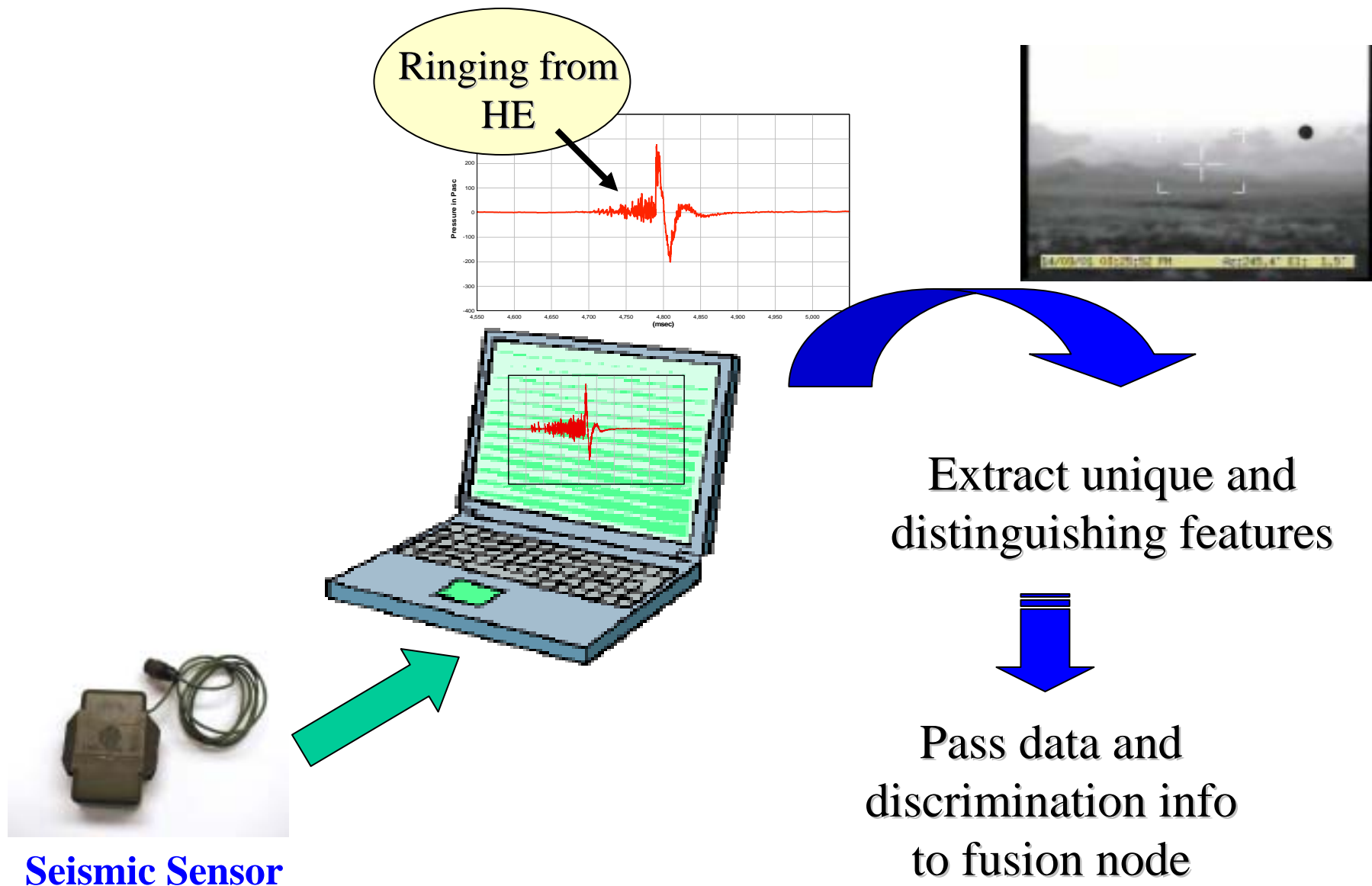
T=3seconds



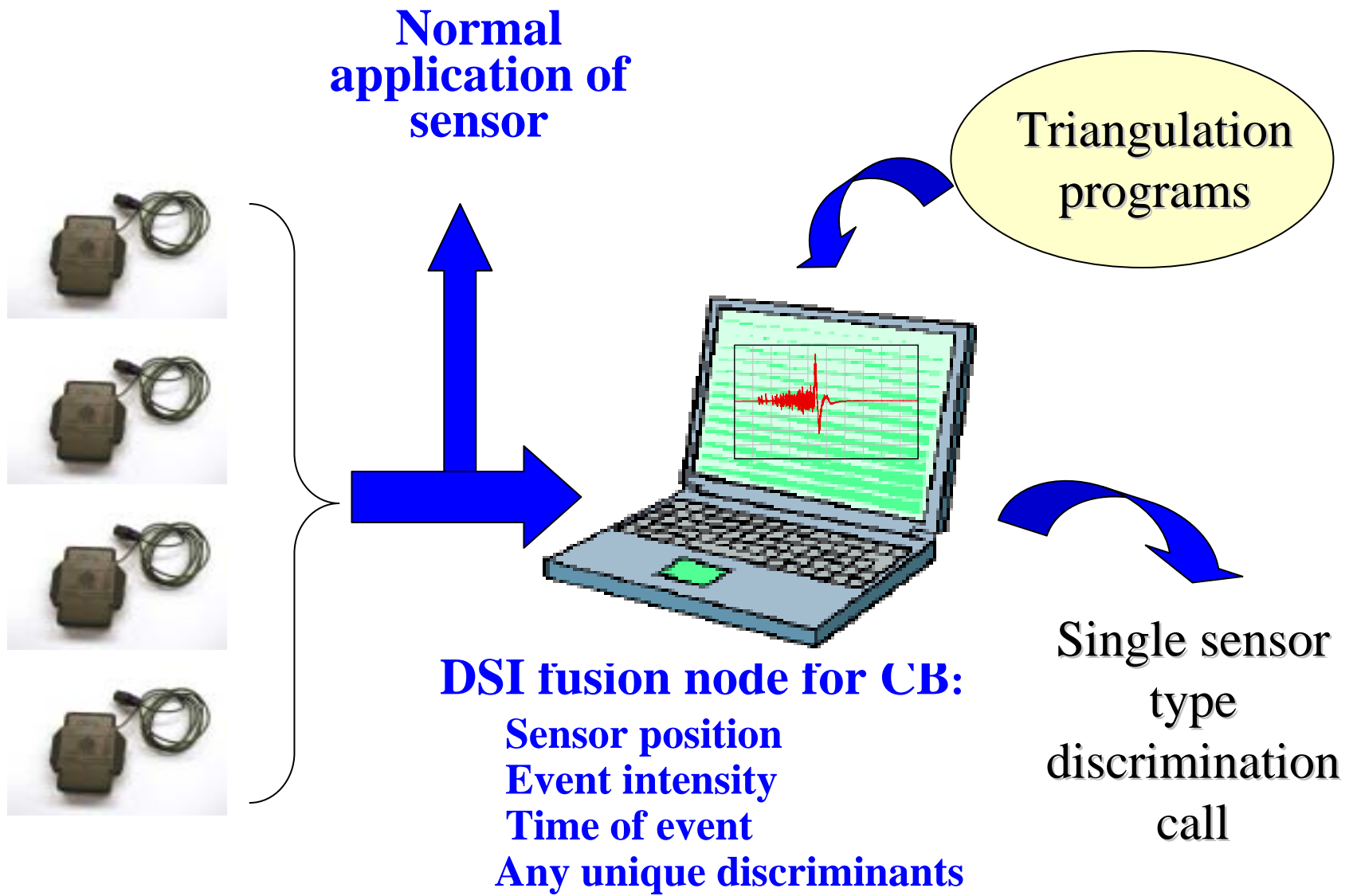
DSI Decision Layers



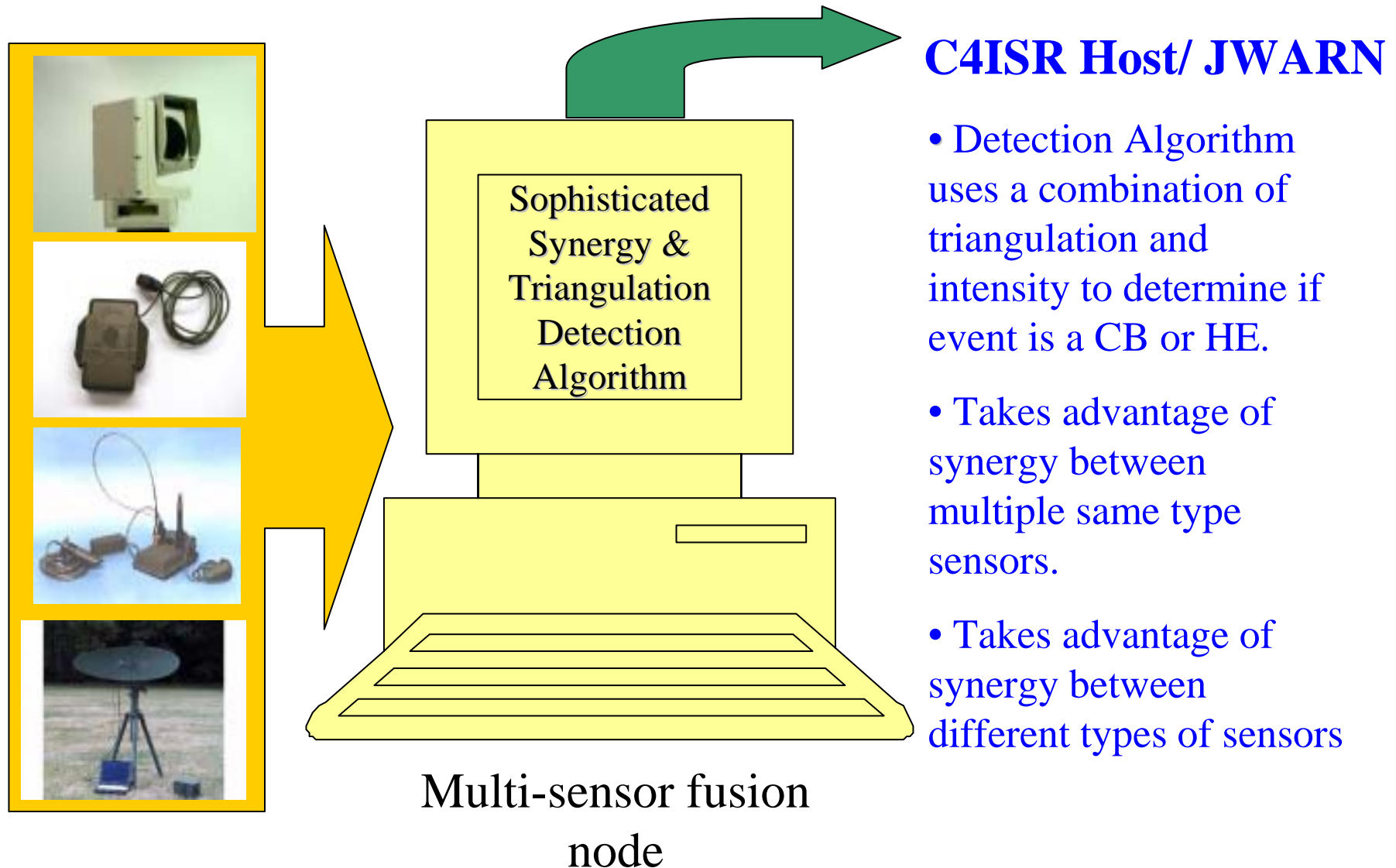
Single Sensor Configuration



Fusion of Common Sensors



Multi, Non-CB Sensor Fusion





Overall

- Disparate, non-CB, intrusion sensors have information that can be used to make a determination
- Information is already in the battlefield
- Provides early warning to soldiers of CB event
- Can allow soldier to go from MOPP IV to MOPP II much more easily
- Relieve fatigue of soldier



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